MECHANICAL EVOLUTION AND CHANGING LABOR TYPES

I. INTRODUCTION

The long series of changes in mechanical inventions that have characterized the past century have given rise to corresponding changes in the type and kind of human effort required in the operation of modern machine industry. Evidences of this are everywhere. The green-groomed cabby and the hostler have given way to the trim chauffeur and auto machinist. The rough-and-ready stage-coach driver has long since been replaced by the locomotive engineer. Even the strong and robust Slav with pick and shovel must step aside and witness the mechanical digger which, with the guidance of a single engineer, can dig more trenches in a day than fifty laborers could have accomplished in a week.

Do the sweeping changes brought in by our ever-evolving manufacturing world call for a higher or lower type of workers—men of higher or lower type as measured by physical and mental requirements? On this significant social problem the opinions of leaders in commercial and economic thought present a maze of disagreement and contradiction. Herbert Spencer asserts in no uncertain terms:

> Clearly these adjustments brought in on account of mechanical inventions make the motions of the workman himself relatively automatic. At the same time the monotonous attention required, taxing special parts of the nervous system and leaving others inactive, entails positive as well as negative injury. And while the mental nature becomes deformed, the physical nature, too, undergoes degradations caused by breathing vitiated air at a temperature now in excess, now in defect, and by standing for many hours in a way which unduly taxes the muscular system.[1]

William Morris gives expression to the same condemnation when he states: "Machinery has made of man a mere automaton—a thing without soul and without spirit—an insignificant cog in a mammoth wheel."

[1] Herbert Spencer, *Principles of Sociology*, IV, 253.

In contrast to these denouncements of the advent of new machinery, we find in certain quarters appreciation ardently expressed. Thus Dr. Carroll D. Wright says:

> Machinery necessitates not only the greatest care in preservation but also in operation; so a man who is intelligent enough to learn quickly how to run one machine is usually intelligent enough to learn how to operate another in some other industry. Unskilled and ignorant labor cannot make such sudden turns. . . . . The man who makes the small parts for the small articles and is thus subjected to what is called "the terrible monotony of machine occupation" is not the man who is capable of making whole things but is the man who has been lifted out of some other monotonous calling and by machinery promoted to that labor which calls for the exercise of some intellect. The use of machinery compels sobriety on the part of the operative; there has been no more powerful or effective temperance worker than the machine. Machinery does not degrade labor but elevates it.[1]

Harry Campbell, former general manager of the Pennsylvania Steel Company, meets the same problem from a more practical side:

> While I have found that machinery may increase the number of men, it demands a much higher grade of workman, so that the man who operates the machine is in most cases likely to get a higher wage than the workman who carried on the operation by hand.[2]

Thus the authorities hold antagonistic views with reference to the effects of machinery upon the operatives. Where one sees machinery as "detrimental to labor," another sees his elevation. No doubt the strongly opposed views are to be accounted for in large part by limited observation. In no two industries would the changes have identical effects. Some changes are detrimental, others beneficial, to the worker. This paper deals chiefly with a branch of an industry in which the results have been beneficial. The author does not present the data as typical. Taken alone they of course do not prove any general thesis.

The data here presented were collected in part by the writer when he was employed by the Federal Trade Commission as a special examiner in the steel industries and also in part by a specific investigation of open hearths in eastern Pennsylvania. His intensive investigation extended to forty-seven open hearths located in

[1] C. D. Wright, *Outline of Practical Sociology* (Longmans, Green, & Co.), p. 256.

[2] Harry Campbell, "The Manufactured Properties of Iron and Steel" *Engineering and Mining Journal*, pp. 618, 619.

eastern Pennsylvania, New York, Ohio, and Maryland. This was only a part of a still longer investigation the results of which are to be presented in a volume on *Changing Machinery and Its Influence upon Man*. A less intensive investigation was also made in other branches of the iron and steel industry In carrying out this study of open hearths careful observation was made of each mechanical invention introduced and of the changes in labor requirements resulting from it. Four definite factors were considered throughout the investigation: (1) the nature of the mechanical process introduced; (2) the effect of the new machinery on the safety of the worker; (3) the effect of the new industries on the number of employees required; (4) the higher or lower type of worker demanded by the invention as measured by (*a*) physical needs, (*b*) mental control and intelligence required, and (*c*) wages earned.

II. THE OPEN HEARTH

Before we trace the mechanical changes observed, a description of the open hearth may not be amiss. The open hearth is used in the production of steel which is obtained by adding a small percentage of carbon (say one-fourth of 1 per cent) to pure iron. Pig iron, scrap iron, and scrap steel are used instead of pure iron, and this stock has far more than the needed amount of carbon. The main purpose of the open hearth is therefore that of reducing the high percentage of carbon.

The open-hearth building is a large structure two or three hundred feet in width and sometimes as much as an eighth of a mile in length. Running lengthwise through the center of the building is a row of furnaces, usually four to twenty in number. Each of these furnaces is a complete unit in itself. The furnace is constructed of fire brick and averages about 30 feet in length, from 22 to 25 feet in width, and from 12 to 15 feet in height, not considering the deep foundation.

At the front of each furnace are two or three openings through which the "charge" is introduced. The large doors are lowered and raised by hydraulic or electric power. The inside of the furnace is called the hearth. Here is where the iron is placed so as to be heated and cooked until it has changed sufficiently in chemical

composition to become steel. At the back of the furnace is the tap, or "runner," through which the molten steel is poured from the furnace. The steel is first poured into large kettles, or ladles. These are from 7 to 10 feet deep and from 6 to 12 feet in diameter. Electric cranes carry these ladles, or "hot-pots," as they are called, over the tops of vertical molds into which the steel is placed.

When the molten metal has hardened, these molds are "stripped off" and we have remaining a piece of steel about 12 inches square and from 5 to 8 feet in length, called an ingot.

Let us now turn to a consideration of the different types of work carried on in connection with the open-hearth process. The occupations may be conveniently classified into large groups, the groups being determined largely by the different working levels upon which the labor force operates. The first group is that of the *charging level*. This is the floor from which all the materials are put into the furnace and is about 30 feet from the ground. The second is that of the *pouring level*. This is on the opposite side of the furnace from the charging floor and is about 12 feet from the ground. The third group is the *ground or pit level*. Here on the pit level are placed the molds into which the molten steel is poured. The fourth group has to do with the operation of the *electric cranes*. These, of course, operate overhead. Finally, outside of these four groups, is much *miscellaneous work*, such as skull-cracking, relining ladles, cleaning brick, etc.

With this introduction we may now consider the labor operations performed in each of the foregoing groups, following closely those jobs where marked changes have been made owing to the introduction of machinery.

1. *The charging level.*—The workers on the charging level are the melter, first and second helper, charger, pull-up boys, and gasmen, all of whom are engaged in getting stock and fuel into the hearth and in operating the furnace. Their work has been changed by the charging machine and the mechanical methods of operating gas-producers.

The methods of charging the furnace have had such a marked influence on output and on labor conditions that it will not be out of place to trace them in some detail. The early method of filling

the furnace was by hand. This method consisted in taking a 15-foot bar of iron flattened at one end like a pancake-turner. Upon the flat end of this bar the workers placed the iron and then shoved it into the furnace. The bar, or "peel," as it was termed, would then be withdrawn for another filling.

According to Mr. Scott Greenwalt, formerly superintendent of open hearths at Midland Steel Company, now with the Bethlehem Steel Company, "this work was the hardest and most strenuous of the whole industry. The heavy lifting of iron, the heat, glare, and fumes from the open furnace, combined to make the work most exhausting. Negroes and Irish were employed almost entirely. All wore heavy red flannel shirts to protect themselves from the excessive heat, and if it were not for the rest periods that occurred between the charging times, no human being could have endured the work for a continuous day." In the language of a worker: "It was working aside of hell ahead of time."

Six to eight men were required to fill a small 25-ton furnace by the peel method. To operate six 25-ton furnaces about forty unskilled workers were needed.

The peel method, though still found in Europe, has almost disappeared from American establishments. In 1895 it began to be replaced by the "dumper method." Under this method the iron is hauled to the front of the furnace in iron bins. A crane then picks up the bins one at a time and dumps them into the furnace. In this process the furnace is usually tilted in order to facilitate the dumping. This dumper method was short-lived, for soon after its invention the charging machine came into operation.

The charging machine revolutionized the industry. One skilled employee operating the modern charging machine can stock six to eight furnaces which under the peel method required forty peel-handlers. Besides, the furnaces are now so large that it is doubtful whether under the old method the laborers could distribute the iron sufficiently well for good heating. Greater output was also made possible. Mr. James Gledhill, assistant superintendent of the American Iron and Steel Manufacturing Company, has stated: "The sole factor accounting for the increased output was the charging machine."

The charging machine consists of a broad, electrically propelled platform upon which the operator sits. This platform has projecting in front of it a long steel arm like a battering ram. The end of this, fitting into a steel box holding several tons of iron, picks up the box of stock, shoves it into the hearth, dumps it, and then withdraws from the furnace for a second box. The filled boxes are brought in on narrow-gauge cars which run on tracks parallel to the furnaces. The charging machine is also on wheels and is capable of operation at all the furnaces.

Where pig iron is brought in a molten state directly from the blast furnace to the open hearth, it is carried in many small ladles and dumped into a huge 50-ton collecting ladle called a "mixer." The hot iron is then poured into the furnace by means of an electric crane. When this method of charging the furnace is employed, the number of workers on the charging floor is reduced to the minimum. Only one is required, and he the highly skilled operator of the overhead crane attached to the mixer.

The production of gas occupies an important place in the operation of the open hearth, for it is used for heating the furnace and metal. To produce gas, soft coal is burned in a thick, heavy fire, and the gas given off is collected. The coal clinkers badly, making constant poking necessary to keep the fire going. The old method of doing this was by means of long bars, and where a plant had eight or ten gas-producers eighteen or twenty laborers were required for this work and for filling the producers. Now this poking of the fuel may be done by the Frazer-Talbot and other mechanical producers. These are provided with steel arms which move up and down and prevent the formation of clinkers. The new method has reduced the number of laborers required. According to the assistant superintendent at Steelton only about a third of the former number are needed. Mr. Greenwalt at Lebanon states that "a great reduction has taken place—possibly 75 per cent less than what was formerly needed."

2. *The pouring level.*—The charging and gas production take place on one side of the long row of furnaces. The pouring, casting, pit work, and handling of molds and slag occur on the opposite side. These operations require the pourer or ladleman, the nozzle-setter,

and the nozzle-setter helpers. The pourer has charge of the flow from the hearth into the ladles. He regulates the flow and takes care of the hot slag. The nozzle-setter has control of the tapping from the ladles into the molds. He is assisted by from four to as many as eighteen or twenty men. The platform upon which these men work is on a level with the tops of the molds. At pouring time the men on the ladleman's platform must work with speed. They must work also with great care, for the handling of metal at liquid heat is dangerous under any circumstances.

The only mechanical change on the pouring level is found in the partial substitution of overhead traveling cranes for stationary ram cranes. The ram crane has a ladle attached to a long arm. In the pouring process the ladle is filled and the metal carried out by the long arm over the tops of the molds into which it is placed. When the traveling crane is employed, the ladle is filled at the "ripe" furnace and then carried to the molds, where the ingots are made. The new method is an economy of labor. If many furnaces are ripe for tapping, the older method requires a large force. At Pencoyd, thirty-seven men were at work in the pouring process when two furnaces were being tapped. At Steelton, where the newest type of open hearths are in operation, only twelve men were engaged in this branch of the work.

3. *The ground or pit level.*—Possibly the greatest change in the open hearth affecting the welfare and safety of the laborers is found in the mechanical aides used in the work of the pitmen. Pitmen are those who tend to an endless amount of work in the way of preparing the molds for casting and in cleaning up after the casting or pouring has taken place.

First of all, traveling cranes carrying steel boxes have displaced barrowmen in removing dirt and scrap. Moreover, they have reduced the necessary labor force of pitmen almost one-half.

Secondly, the coming in of the thimble has eliminated a great deal of slag work. The thimble is a hot-pot, or ladle, shaped like a cone standing on its apex. It is very broad at the top (12 feet), and is kept near the "runner" of the hearth so as to catch the overflow of steel and slag. The cranes also drain the dregs of the hot-pots into the thimble. When full, the thimble is carried

out by crane and then by locomotive. Formerly the overflow was allowed to run on the ground, and then after cooling was broken up by laborers with heavy sledges and treated as scrap.

Thirdly, the introduction of molds placed upon cars has wrought a big change. It is necessary to describe in detail the different methods of handling the molds to see clearly the benefits from the newer method.

Under the old method the steel was poured from the stationary crane into molds arranged in two or three semicircular rows in a pit near the ladle crane. Around the base of these molds the pitmen worked. When the steel had hardened sufficiently, the overhead crane, with its chains fastened to the lugs of the mold, stripped the mold from the ingot. If the mold stuck, the pitman took a heavy sledge and loosened it. Work among these hot molds was extremely dangerous. One superintendent asserted that more open-hearth accidents had happened to pitmen than to all other employees. All will remember the horrible accident at one steel plant where the dropping of a ladle buried three pitmen in molten metal.

At Harrisburg, at Steelton, at Lebanon, at Lackawanna, at Bethlehem—in fact, in most plants—the molds are now placed on cars and as they are filled are drawn away by locomotives.

Fourthly, the mechanical stripper has removed the men from the pit and the pit's dangers. Instead of having pitmen fasten the crane chains to the molds, so as to strip the ingots, this gigantic machine, 35 feet in height, places its huge hand over the mold and tightly grasps it. As the mold is being lifted by this electric-power machine a plunger forces the ingot from the mold. Where eight or ten pitmen were constantly at work helping a crane to do stripping, the mechanical stripper operates with only one employee. The operator of the stripper is treated on the same basis as a crane-man, is paid the same wages, and has the same rank. Here is another instance where mental power has been substituted for physical strength. Skill is required to operate levers, not muscles to swing sledges.

Thus the changes on the ground level have eliminated much of the "common labor" and have greatly reduced the hazard.

4. *The cranemen's level.*—The traveling crane has had a marked influence in removing common unskilled labor from the steelmills. The carrying and lifting operations which have gone from muscles to mechanical power through the coming in of the crane is a shift which connotes a profound influence upon labor types. Most of the large and heavy processes of the modern open hearth are made possible on account of this change. The handling of the mixer described above, the carrying of ladles or "hot-pots" from the furnace taps to the molds, the lifting of the molds themselves, and the handling of brick, sand, and slag in pit and repair work are all instances of large-scale processes coming with the crane. This of course means a going out of physical labor. Take as one instance the handling of the slag. "What fifteen or twenty men formerly could haul away in a day by means of wheelbarrows is now carried away in two or three trips, by the use of cranes."

5. *Miscellaneous outside labor.*—We have finally to deal with the miscellaneous outside labor employed in the open-hearth process. When a ladle is emptied some of the steel is certain to remain and harden. This is dumped from the ladle and, from its shape, takes the name of a skull. Inasmuch as this is generally pure steel, it is valuable for remelting. An important outside operation found at all open hearths is the breaking of skulls so as to render them small enough to enter the furnace doors.

When two open-hearth operators went to the Midland Steel Company as superintendents of the rolling-mills and open hearths, the first demand they made in the way of machinery was for a magnetic drop-ball apparatus and for a Hayward bucket, both to be used for cracking skulls and loading them upon cars to be taken to the charging floor. One of these men stated that "twenty to twenty-five 'Hunkies' had been employed to break up these skulls, at a cost of $30 to $35 a day in wages. With the magnet and ball all the steel skulls were broken and collected by four workers—two skilled men to operate the machinery and two laborers for helping."

The drop-ball is operated by attaching a metal plate to an overhead crane, the plate being so arranged that it can be powerfully magnetized. This plate then picks up a heavy iron ball 30

inches or so in diameter, and weighing over a ton, and lifts it to a height of 25 feet directly over a skull, after which the magnet is broken. With a thud the skull is shattered by the falling ball into six or eight pieces sufficiently small to enter the furnace door. The Hayward bucket is a mechanical shovel with large protruding teeth. This operates on a revolving electric crane and scoops up the steel pieces and places them on cars.

Around every open hearth repairs to furnaces are in progress. Many workers, such as bricklayers, bricklayers' helpers, and common laborers, are at work. The laborers clean out furnaces, clean brick, etc., while the bricklayers with their helpers construct new furnaces. It was impossible to get data for these employees because of the great variety and kind of work which they were doing and because their employment is usually by other departments and not under the open-hearth control.

III. EFFECT OF MECHANICAL EVOLUTION ON LABOR

Having outlined the nature of the open-hearth process and the changes in the various types of work that have occurred, we may now inquire what effects these changes have had upon labor: first, upon the type of laborers required; secondly, upon the saving in labor power that is affected; and thirdly, upon wages.

In general, one finds in the open hearth a reduction in the number of unskilled laborers required and an increased demand for skilled or semi-skilled workers. Mental control rather than physical power appears to be the main requisite. For instance, with the introduction of the charging machine the nature of the change in the type of labor required is stated by an official who was questioned on the matter as follows. Pointing to the small stature and light weight of an operator he said: "There is your answer; no muscle, no physical resistance; just sufficient skill and cleverness to operate six levers. Imagine such a little shrimp trying to handle a peel."

Similarly, with the introduction of cranes, especially electric cranes, the change in the type of labor needed was very marked. In every mill investigated the cranemen, save for exceptional instances, were native whites paid from 8 to 10 cents an hour more

than common laborers. Not physical power, but skill and vigilance are demanded of cranemen. A wrong movement of a lever might easily spill tons of metal, topple ingots, or crush furnaces. If costly mistakes are to be avoided, eternal vigilance must be exercised. Accidently upset a wheelbarrow, and what does it matter?

With reference to wages it is impossible to present conclusive results, as the data are inadequate. In some occupations wages are on a time basis, in many the men are paid on a tonnage basis, while in others a combination of the two bases is used. However, there is some evidence, which is presented here for what it is worth.

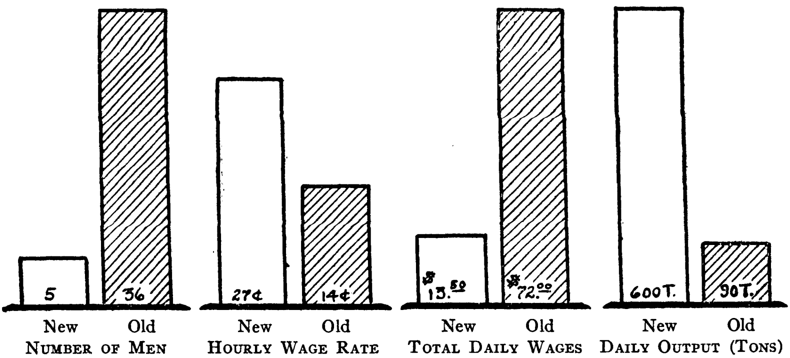

Fig. 1.—Workers employed and labor costs in the open-hearth industry

Under the old peel method, peel-chargers at Steelton, Pennsylvania, were paid 13 cents an hour and at Harrisburg 15 cents an hour. Everywhere under this method the wages were about the same as those of unskilled laborers. But with the charging machines which replaced the peel method, at one plant today the operator is paid $27\frac{1}{2}$ cents an hour; at another $28\frac{1}{2}$ cents; and at two other plants 32 cents an hour.

One superintendent has worked out a comparison of labor costs (Table I) and also the approximate outputs under the peel and under the charging-machine methods. He has included the necessary locomotive shifting crew in his estimates for the methods. While these figures for the peel method are only an approximation, it is believed that they are substantially correct.

TABLE I

Method	No. of Men	Rate of Wages	Total Wages Bill	Output in Tons
Peel	36	Common labor then 14 cents, now 20 cents	$72.00	90
Charging machine and tracks	5	27 cents	13.50	600

Charting these figures we obtain the result shown in Fig. 1.

The estimates given in Table II indicate the importance of the change from the hand or sledge-breaking method to the drop-ball and bucket method.

TABLE II

	No. of Men	Total Daily Wages	Wages per Hour
Hand or sledge breaking	20	$36.00	$0.18
Drop ball and bucket	4	9.10	0.22¾

The estimate given in Table III, based on the experience of one employer, shows the total amount of labor required to operate an old and a modern furnace. The figures are for a 50-ton furnace for twenty-four hours, with twelve-hour shifts.

TABLE III

Occupation	Older Open Hearth	Modern Open Hearth
Melters	2	2
Helpers (first)	4	4
Helpers (second)	8	8
Ladlemen	2	2
Nozzle-setter	2	2
Nozzle-setter helpers	6	6
Door boys	8	8
Stockers, gasmen, and chargers	38	10
Pitmen	32	14
Stripping ingots	14	4
Skull cracking	26	4
Total	142	58

The table also throws light upon the problem of the change in type of laborer which we were discussing above. If the table be

analyzed with a view to dividing the labor into skilled and unskilled, or, better, to divide the labor into that which is predominantly physical and that which in the main is mental, the foregoing figures would give the results shown in Table IV.

TABLE IV

Type of Work	Old	New
Mental control (skilled labor)......	10	28
Physical power (unskilled labor)....	132	30
Total........................	142	58

Fig. 2 will perhaps show this change in a more impressive way. It should be noted that unskilled labor in the modern industry drops to less than one-fourth of the former requirement, while skilled workers increase with new machinery to approximately three times the number needed under the older methods.

IV. TENDENCIES IN OTHER INDUSTRIES

Having reviewed these detailed operations in the open-hearth industry, we may make a brief reference to some other industries in which much the same thing is witnessed.

In the blast furnaces, for instance, where crude iron is made, the same tendency is found, though perhaps not so marked as in open hearths. The skip-hoist, larry-car, and dumping bin have removed the need of barrowmen, top-fillers, bottom-fillers, and hoistmen—all unskilled laborers. Larrymen and larrymen helpers, who are either skilled or semi-skilled, now do the work, and where thirty men were formerly needed, now only five workers are required. Again, in the casting of pig iron heavy, muscular men were found handling pig iron in the sand beds under the older methods. They were what

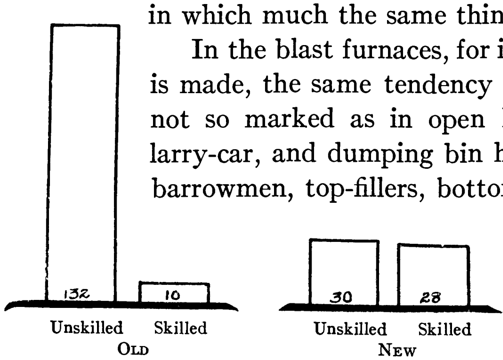

FIG. 2.—Changing labor types in the open-hearth industry.

Taylor called "gorilla men." Today a pig-casting machine has removed all of these crude and rough, unskilled laborers.

The finishing mills of the steel industry—such as blooming, slab, rail, and merchant mills—all bear witness to approximately the same changes noted in the open hearth. Where in earlier times the rolling of steel bars, slabs, or rails was done with tongs and peels, by strong men who pulled and tugged at the hot metal, today one finds this same work performed by a movable electric platform operated by skilled workers throwing levers. Electric cranes in all these industries have removed much of the physical work of lifting and carrying.[1]

V. CONCLUSIONS

In drawing definite conclusions regarding the effects that changing machinery has upon labor in the steel industry we shall keep to the facts as found in the open-hearth studies.

These facts are sufficient to drive home the importance and far-reaching influence that mechanical invention has upon the workers. Throughout the open-hearth plant are seen today new methods, new machinery, and old types of workers thrown into the discard. The industry is in constant flux, and everywhere this replacing process continues. Observations from data collected warrant the following conclusions:

First, the open-hearth industry during the last forty years has introduced with accelerated speed mechanical processes. Within

[1] Not in the steel industries only, but in other lines of production also, is this trend to be observed. Before me are the facts of the Kimberly Clark Paper Company, one of the largest paper-mills of our country. The employees are divided into those who operate machines and those who do non-mechanical work. The machine workers average approximately 40 per cent more in wages than the unskilled workers. Again, the labor turnover among the unskilled in this mill is six times that of the men operating machinery. Miss Mary Baker, the employment manager, has stated: "The unskilled worker is not a steady worker; he is never a careful worker. Those operating machines show an enthusiasm and interest for their work never found in the other group. I am pleased to see more machine work coming into the industry, for I believe it creates a feeling of responsibility and steadiness among the workers, thereby stabalizing the industry as a whole."

Besides the above industries noted, the writer has in process of compilation data from outside-construction firms, canning industries, and coal- and ore-loading companies. Already it is being seen that in these industries invention demands skill, care, and control which are not needed by those who work in non-mechanical pursuits.

this time have developed the charging machine, stripper, skull-cracker, and modern handling of ingot molds—all more or less machinery of tremendous size, complexity, and capacity; machinery whose operation in every single instance has displaced operations that were formerly carried on by hand. These colossal machines today are operated by skilled hands who have displaced unskilled laborers who wheeled the barrow, slung the sledge, or heaved the heavy peel.

Secondly, the new machiney calls for fewer workers in open-hearth production. A visitor at a modern plant is not surprised by the great number of workers, but rather by their comparative fewness. As one visitor to an open hearth in full operation expressed it, "Don't any people work in this factory?"

In other words, the mechanical inventions introduced require far less labor for carrying on specific operations. The charging machine has displaced thirty or thirty-five peel handlers; displacement by the other machines has been greater or less. This does not mean, however, that fewer men are working in the open hearths of the United States today than were employed in earlier times. The steel industry has grown and is still growing so rapidly that an increasing number of men is needed in the industry.[1]

The tendency toward relatively fewer men is but one step nearer efficient production. The situation is somewhat akin to Taylor's ideal, "Higher wage with a lower labor cost"—a condition beneficial both to employer and employees.

Thirdly, the work has been made safer. The popular notion that greater machinery means more danger to workers finds no substantiation whatever in fact, as far as open-hearth occupations are concerned. Not more but fewer accidents have occurred with the coming of mechanical appliances. Very often machines such as the stripper, which does away with the need of pitmen, have displaced the dangerous occupations. One superintendent of open hearths claimed that the coming in of the mechanical methods

[1] In 1870 approximately 27,500 workers were employed in the crude steel industry, while in 1909, 43,000 were working. Tonnage during this same period increased from approximately 2,000,000 tons to 35,000,000 tons.

has reduced accidents to pitmen at least 75 per cent. In this employer's plant during one year when the old pit methods were in vogue, sixty-eight were injured, fourteen of them fatally. In the modern plant, in 1916, twenty-two injuries were recorded, one of which was fatal. In the open-hearth industry much of the dangerous work has been done away with simply because the workers in the dangerous occupations are no longer needed. Machinery now does the work.

Fourthly, the last consideration, and one of no small importance, is the changing type of man that comes with the new machinery. The results in the open hearth throughout show without question that a greater mentality and a more skilled worker is needed. Possibly one of the best tests of this change of mental types rests in terms of increased costs of error that come with the growth of machinery. In the open hearths studied one factor that stood out prominently was the costliness of mistakes likely to be made by workers. The costliness of error is in direct ratio to the increase in mechanical methods. As one superintendent put it, "One error in judgment on the part of the operator of a charging machine may so injure either the machine or furnace or both that as much as two or three weeks may be required to make needed repairs." He was just as emphatic regarding the cranemen: "They must be exceedingly careful, working as they do at all times with molten metal over the heads of workers and near ingot molds that topple with a slight jar. Topple a ladle into the pit-floor and no end of cost and disaster result."

Mr. Magnus Alexander, who has been making extensive studies of labor turnover, tells us that the hiring and firing of a day laborer costs to the employer as much as $40. In one of the steel plants studied the superintendent asserted that to replace the loss of one employee operating one of the larger overhead cranes would, in his estimation, cost at least $750. He based his calculations on the great danger that ensues to both machinery and workers when a green man is put on the job.

Facts in the open-hearth industry bear out Dr. Carroll D. Wright when he declares that muddled brains are in danger when working near complex machinery. The reader should also observe

that complex machines are in danger when muddled brains operate them. A more complex machine and a higher type of mentality on the part of the worker become the natural adjustment.

The change, therefore, in open hearths is observed in mental control as against physical effort—a shift from muscular power to intellectual skill. The strong of body are no longer required. Keenness, carefulness, cautiousness, and mental alertness have become the requisites for success.

CHARLES REITELL

LAWRENCE COLLEGE